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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/714,465	11/14/2003	Jinquan Dai	42P17829	2488
8791 7590 08/06/2008 BLAKELY SOKOLOFF TAYLOR & ZAFMAN LLP 1279 OAKMEAD PARKWAY SUNNYVALE, CA 94085-4040				
EXAMINER				
WANG, BEN C				
ART UNIT		PAPER NUMBER		
2192				
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08/06/2008		PAPER		

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary

Application No.

10/714,465

Applicant(s)

DAI ET AL.

Examiner

BEN C. WANG

Art Unit

2192

Period for Reply -- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 12 June 2008.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-36 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-4, 8-14, 18-21, 26 and 31-36 is/are rejected.
- 7) ☒ Claim(s) 5-7, 15-17, 22-25 and 27-30 is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☐ Information Disclosure Statement(s) (PTO/SB08)
Paper No(s)/Mail Date _____
- 4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date _____
- 5) ☐ Notice of Informal Patent Application
- 6) ☐ Other: _____

DETAILED ACTION

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on June 12, 2008 has been entered.

2. Applicant's amendment dated June 12, 2008, responding to the Advisory Action mailed May 14, 2008 and the Office Action mailed December 31, 2007 provided in the rejection of claims 1-36, wherein claims 1, 11, 21, 22, 26, 31, and 34 are amended.

Claims 1-36 remain pending in the application and which have been fully considered by the examiner.

Applicant's arguments with respect to claims rejection have been fully considered but are moot in view of the new grounds of rejection – see *Paulin et al.*, art made of record, as applied hereto.

Claim Rejections – 35 USC § 103(a)

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the

invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

3. Claims 1, 11, 21, 26, 31, and 34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lakshmanamurthy et al. ("*Network Processor Performance Analysis Methodology*", Aug. 15, 2002, *Intel Technology Journal*) (hereinafter 'Lakshmanamurthy') in view of Paulin et al. ("*Network Processors: A Perspective on Market Requirements, Processor Architectures and Embedded S/W Tools*, 2001 *IEEE*, pp. 420-427) (hereinafter 'Paulin' - art made of record)

4. **As to claim 1** (Currently Amended), Lakshmanamurthy discloses a method comprising:

- configuring one or more processors into a D-stage processor pipeline (e.g., Sec. of "ABSTRACT", 1st Para – this paper describes the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running on the IXP 2400 network processor, the second-generation IXA network processor; P. 19, L-Col., 3rd Para, Lines 4-9 – this methodology involves dividing the application into pipeline blocks.. and latency budget for each pipeline element, and mapping the application blocks to software paradigms and the hardware resources)

Lakshmanamurthy discloses the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running

on the IXP2400 network processor (e.g., Abstract, 1st Para), but does not explicitly disclose the followings:

- transforming a sequential network application program into D-pipeline stages that collectively perform the an infinite packet processing state (PPS) loop of the sequential network application programs; and
- executing the D-pipeline stages in parallel within the D-stage processor pipeline to provide the infinite parallel execution of PPS loop of the sequential network application program.

However, in an analogous art of *Network Processors: A Perspective on Market Requirements, Processor Architectures and Embedded SW Tools*, Paulin discloses the followings:

- transforming a sequential network application program into D-pipeline stages that collectively perform the an infinite packet processing state (PPS) loop of the sequential network application programs (e.g., Sec. 2 – Network Processing Unit Architecture, 3rd Para - ... A network processor ... integrated set of micro-coded or hardwired accelerated engines ... high-speed interconnect and media interfaces to tackle packet processing close to the wire. It uses pipelining, parallelism, and multi-threading to hide latency. IT has good data flow management and high-speed internal communication support. It has ability to access co-processor and is closely coupled with the media interface; Sec. 3.2 – FlexCC: Compilation Technology); and

- executing the D-pipeline stages in parallel within the D-stage processor pipeline to provide the infinite parallel execution of PPS loop of the sequential network application program (e.g., Fig. 2 – STMicroelectronics NPU Architecture Overview; Sec. 2.2 NPU Design at STMicroelectronics, 2nd Para - ... instruction set definition, pipelining, parallelism, multithreading, fast interconnect, and semiconductor technology all combine to produce a network processor capable of OC-192 speeds and higher; 4th Para - ... achieved via pipelining ... a chain of pipelined processing units and flexible programmable elements; last Para - ... each packet processing engine will process a packet. When the packet processor is done, it will give back the packet header and pick up the next ready packet header to process; Sec. 3.6 – Application of FlexWare to the STMicroelectronics Network Processor; Sec. 3.6 – FlexWare Outlook)

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Paulin into the Lakshmanamurthy's system to further provide the followings in Lakshmanamurthy system:

- transforming a sequential network application program into D-pipeline stages that collectively perform the an infinite packet processing state (PPS) loop of the sequential network application programs; and
- executing the D-pipeline stages in parallel within the D-stage processor pipeline to provide the infinite parallel execution of PPS loop of the sequential network application program.

The motivation is that it would further enhance the Lakshmanamurthy's system by taking, advancing and/or incorporating Paulin's system which offers significant advantages that the STMicroelectronics *FlexWare* embedded software environment is the basis of our NPU embedded S/W toolset, which will allow us to address the rapid changes in networking needs and customer requirement as once suggested by Paulin (e.g., Sec. 4 - Conclusion, 2nd Para)

5. **As to claim 11** (Currently Amended), Lakshmanamurthy discloses an article of manufacture including a machine readable medium having stored thereon instructions which may be used to program a system to perform a method, comprising:

- configuring one or more processors into a D-stage processor pipeline (e.g., Sec. of "ABSTRACT", 1st Para – this paper describes the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running on the IXP 2400 network processor, the second-generation IXA network processor; P. 19, L-Col., 3rd Para, Lines 4-9 – this methodology involves dividing the application into pipeline blocks.. and latency budget for each pipeline element, and mapping the application blocks to software paradigms and the hardware resources)

Lakshmanamurthy discloses the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running on the IXP2400 network processor (e.g., Abstract, 1st Para), but does not explicitly disclose the followings:

- transforming a sequential network application program into D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program; and
- executing the D-pipeline stages in parallel within the D-stage processor pipeline to provide parallel execution of the infinite PPS loop of the sequential network application program.

However, in an analogous art of *Network Processors: A Perspective on Market Requirements, Processor Architectures and Embedded S/W Tools*, Paulin discloses the followings:

- transforming a sequential network application program into D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program (e.g., Sec. 2 – Network Processing Unit Architecture, 3rd Para - ... A network processor ... integrated set of micro-coded or hardwired accelerated engines ... high-speed interconnect and media interfaces to tackle packet processing close to the wire. It uses pipelining, parallelism, and multi-threading to hide latency. IT has good data flow management and high-speed internal communication support. It has ability to access co-processor and is closely coupled with the media interface; Sec. 3.2 – FlexCC: Compilation Technology); and
- executing the D-pipeline stages in parallel within the D-stage processor pipeline to provide parallel execution of the infinite PPS loop of the sequential network application program (e.g., Fig. 2 – STMicroelectronics NPU Architecture

Overview; Sec. 2.2 NPU Design at STMicroelectronics, 2nd Para - ... instruction set definition, pipelining, parallelism, multithreading, fast interconnect, and semiconductor technology all combine to produce a network processor capable of OC-192 speeds and higher; 4th Para - ... achieved via pipelining ... a chain of pipelined processing units and flexible programmable elements; last Para - ... each packet processing engine will process a packet. When the packet processor is done, it will give back the packet header and pick up the next ready packet header to process; Sec. 3.6 – Application of FlexWare to the STMicroelectronics Network Processor; Sec. 3.6 – FlexWare Outlook)

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Paulin into the Lakshmanamurthy's system to further provide the followings in Lakshmanamurthy system:

- transforming a sequential network application program into D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program; and
- executing the D-pipeline stages in parallel within the D-stage processor pipeline to provide parallel execution of the infinite PPS loop of the sequential network application program

The motivation is that it would further enhance the Lakshmanamurthy's system by taking, advancing and/or incorporating Paulin's system which offers significant advantages that the STMicroelectronics *FlexWare* embedded software environment is the basis of our NPU embedded S/W toolset, which will allow us to address the rapid

changes in networking needs and customer requirement as once suggested by Paulin (e.g., Sec. 4 - Conclusion, 2nd Para)

6. **As to claim 21** (Currently Amended), Lakshmanamurthy discloses a method comprising:

- constructing a flow network model from a sequential network application program (e.g., Sec. of "ABSTRACT", 1st Para – this paper describes the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running on the IXP 2400 network processor, the second-generation IXA network processor; Sec. Introduction, 2nd Para, Lines 18-23 - .. in analyzing the performance of networking applications running on the IXP2400 network processor and presents a case study using the IPv4 forwarding + DiffServ application; 3rd Para - ... a detailed data movement model of the target application. This model describes the various operations performed by the network processor on every received packet);
- cutting the flow network model into a plurality of preliminary pipeline stages (e.g., P. 19, L-Col., 3rd Para, Lines 4-9 – this methodology involves diving the application into pipeline blocks.. and latency budget for each pipeline element, and mapping the application blocks to software paradigms and the hardware resources).

Lakshmanamurthy discloses the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running

on the IXP2400 network processor (e.g., Abstract, 1st Para), but does not explicitly disclose:

- transforming the preliminary pipeline stages to perform control flow and variable transmission therebetween to form D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the infinite PPS loop of the sequential network application program.

However, in an analogous art of *Network Processors: A Perspective on Market Requirements, Processor Architectures and Embedded SW Tools*, Paulin discloses:

- transforming the preliminary pipeline stages to perform control flow and variable transmission therebetween to form D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the infinite PPS loop of the sequential network application program (e.g., Sec. 2 – Network Processing Unit Architecture, 3rd Para - ... A network processor ... integrated set of micro-coded or hardwired accelerated engines ... high-speed interconnect and media interfaces to tackle packet processing close to the wire. It uses pipelining, parallelism, and multi-threading to hide latency. IT has good data flow management and high-speed internal communication support. It has ability to access co-processor and is closely coupled with the media interface; Sec. 3.2 – FlexCC: Compilation Technology; Fig. 2 – STMicroelectronics NPU Architecture Overview; Sec. 2.2 NPU Design at

STMicroelectronics, 2nd Para - ... instruction set definition, pipelining, parallelism, multithreading, fast interconnect, and semiconductor technology all combine to produce a network processor capable of OC-192 speeds and higher; 4th Para - ... achieved via pipelining ... a chain of pipelined processing units and flexible programmable elements; last Para - ... each packet processing engine will process a packet. When the packet processor is done, it will give back the packet header and pick up the next ready packet header to process; Sec. 3.6 – Application of FlexWare to the STMicroelectronics Network Processor; Sec. 3.6 – FlexWare Outlook)

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Paulin into the Lakshmanamurthy's system to further provide the following in Lakshmanamurthy system:

- transforming the preliminary pipeline stages to perform control flow and variable transmission therebetween to form D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the infinite PPS loop of the sequential network application program.

The motivation is that it would further enhance the Lakshmanamurthy's system by taking, advancing and/or incorporating Paulin's system which offers significant advantages that the STMicroelectronics *FlexWare* embedded software environment is the basis of our NPU embedded S/W toolset, which will allow us to address the rapid

changes in networking needs and customer requirement as once suggested by Paulin (e.g., Sec. 4 - Conclusion, 2nd Para)

7. **As to claim 26** (Currently Amended), Lakshmanamurthy discloses an article of manufacture including a machine readable medium having stored thereon instructions which may be used to program a system to perform a method, comprising:

- constructing a flow network model from a sequential network application program (e.g., Sec. of "ABSTRACT", 1st Para – this paper describes the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running on the IXP 2400 network processor, the second-generation IXA network processor; Sec. Introduction, 2nd Para, Lines 18-23 - .. in analyzing the performance of networking applications running on the IXP2400 network processor and presents a case study using the IPv4 forwarding + DiffServ application; 3rd Para - ... a detailed data movement model of the target application. This model describes the various operations performed by the network processor on every received packet);
- cutting the flow network model into a plurality of preliminary pipeline stages (e.g., P. 19, L-Col., 3rd Para, Lines 4-9 – this methodology involves diving the application into pipeline blocks.. and latency budget for each pipeline element, and mapping the application blocks to software paradigms and the hardware resources)

Lakshmanamurthy discloses the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running

on the IXP2400 network processor (e.g., Abstract, 1st Para), but does not explicitly disclose:

- transforming the preliminary pipeline stages to perform control flow and variable transmission therebetween in order to form D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the infinite PPS loop of the sequential network application program.

However, in an analogous art of *Network Processors: A Perspective on Market Requirements, Processor Architectures and Embedded SW Tools*, Paulin discloses:

- transforming the preliminary pipeline stages to perform control flow and variable transmission therebetween in order to form D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the infinite PPS loop of the sequential network application program (e.g., Sec. 2 – Network Processing Unit Architecture, 3rd Para - ... A network processor ... integrated set of micro-coded or hardwired accelerated engines ... high-speed interconnect and media interfaces to tackle packet processing close to the wire. It uses pipelining, parallelism, and multi-threading to hide latency. It has good data flow management and high-speed internal communication support. It has ability to access co-processor and is closely coupled with the media interface; Sec. 3.2 – FlexCC: Compilation Technology; Fig. 2 – STMicroelectronics NPU Architecture Overview; Sec. 2.2 NPU Design at

STMicroelectronics, 2nd Para - ... instruction set definition, pipelining, parallelism, multithreading, fast interconnect, and semiconductor technology all combine to produce a network processor capable of OC-192 speeds and higher; 4th Para - ... achieved via pipelining ... a chain of pipelined processing units and flexible programmable elements; last Para - ... each packet processing engine will process a packet. When the packet processor is done, it will give back the packet header and pick up the next ready packet header to process; Sec. 3.6 – Application of FlexWare to the STMicroelectronics Network Processor; Sec. 3.6 – FlexWare Outlook)

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Paulin into the Lakshmanamurthy's system to further provide the following in Lakshmanamurthy system:

- transforming the preliminary pipeline stages to perform control flow and variable transmission therebetween in order to form D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the infinite PPS loop of the sequential network application program.

The motivation is that it would further enhance the Lakshmanamurthy's system by taking, advancing and/or incorporating Paulin's system which offers significant advantages that the STMicroelectronics *FlexWare* embedded software environment is the basis of our NPU embedded S/W toolset, which will allow us to address the rapid

changes in networking needs and customer requirement as once suggested by Paulin (e.g., Sec. 4 - Conclusion, 2nd Para)

8. **As to claim 31** (Currently Amended), Lakshmanamurthy discloses an apparatus, comprising:

- a processor (e.g., Sec. of "ABSTRACT", 1st Para – this paper describes the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running on the IXP 2400 network processor, the second-generation IXA network processor; Fig. 1 – IXP 2400 external interface, element of "IXP 2400"; P. 20, R-Col., 1st Para; P. 21, L-Col., 3rd Para – IXP 2400 contains eight multi-threaded, packet-processing micro-engines; these micro-engines are highly programmable packet processors and support multi threading of up to eight threads each; each micro-engine provides a variety of network processing functions in hardware; P. 21, R-Col., 2nd Para – the IXP 2400 also has an integrated low-power general-purpose Intel® Xscale™ micro-architecture core; the integrated Xscale™ process offers ample processing power for running control plane software);
- a memory coupled to the processor (e.g., P. 20, L-Col., 4th Para – extern DRAM and SRAM; P. 20, L-Col., 4th Para – P. 21, L-Col., 1st Para – the SRAM is primarily used for packet descriptors, queue descriptors, counters, and other data structures; Fig. 2 – IXP 2400 internal architecture, elements of "QDR SRAM", "DDRAM"; Fig. 3 – IXP 2400-based OC-48 line card configuration, element of "DDR SDRAM")

Lakshmanamurthy discloses the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running on the IXP2400 network processor (e.g., Abstract, 1st Para), but does not explicitly disclose:

- the memory including a compiler to cause transformation of a sequential network application program into D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the D-pipeline stages within a D-stage processor pipeline to provide parallel execution of the infinite PPS loop of the sequential network application program.

However, in an analogous art of *Network Processors: A Perspective on Market Requirements, Processor Architectures and Embedded S/W Tools*, Paulin discloses:

- the memory including a compiler to cause transformation of a sequential network application program into D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the D-pipeline stages within a D-stage processor pipeline to provide parallel execution of the infinite PPS loop of the sequential network application program (e.g., Sec. 2 – Network Processing Unit Architecture, 3rd Para - ... A network processor ... integrated set of micro-coded or hardwired accelerated engines ... high-speed interconnect and media interfaces to tackle packet processing close to the wire. It uses pipelining, parallelism, and multi-threading to hide latency. IT

has good data flow management and high-speed internal communication support. It has ability to access co-processor and is closely coupled with the media interface; Sec. 3.2 – FlexCC: Compilation Technology; Fig. 2 – STMicroelectronics NPU Architecture Overview; Sec. 2.2 NPU Design at STMicroelectronics, 2nd Para - ... instruction set definition, pipelining, parallelism, multithreading, fast interconnect, and semiconductor technology all combine to produce a network processor capable of OC-192 speeds and higher; 4th Para - ... achieved via pipelining ... a chain of pipelined processing units and flexible programmable elements; last Para - ... each packet processing engine will process a packet. When the packet processor is done, it will give back the packet header and pick up the next ready packet header to process; Sec. 3.6 – Application of FlexWare to the STMicroelectronics Network Processor; Sec. 3.6 – FlexWare Outlook)

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Paulin into the Lakshmanamurthy's system to further provide the following in Lakshmanamurthy system:

- the memory including a compiler to cause transformation of a sequential network application program into D-pipeline stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the D-pipeline stages

within a D-stage processor pipeline to provide parallel execution of the infinite PPS loop of the sequential network application program.

The motivation is that it would further enhance the Lakshmanamurthy's system by taking, advancing and/or incorporating Paulin's system which offers significant advantages that the STMicroelectronics *FlexWare* embedded software environment is the basis of our NPU embedded S/W toolset, which will allow us to address the rapid changes in networking needs and customer requirement as once suggested by Paulin (e.g., Sec. 4 - Conclusion, 2nd Para)

9. **As to claim 34** (Currently Amended), Lakshmanamurthy discloses a system comprising:

- a processor (e.g., Sec. of "ABSTRACT", 1st Para – this paper describes the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running on the IXP 2400 network processor, the second-generation IXA network processor; Fig. 1 – IXP 2400 external interface, element of "IXP 2400"; P. 20, R-Col., 1st Para; P. 21, L-Col., 3rd Para – IXP 2400 contains eight multi-threaded, packet-processing micro-engines; these micro-engines are highly programmable packet processors and support multi threading of up to eight threads each; each micro-engine provides a variety of network processing functions in hardware; P. 21, R-Col., 2nd Para – the IXP 2400 also has an integrated low-power general-purpose Intel® Xscale™ micro-architecture core; the

integrated Xscale™ process offers ample processing power for running control plane software);

- a memory controller coupled to the processor (e.g., P. 21, L-Col., 3rd Para, Lines 13-14 – the memory controllers facilitate efficient access to the of-chip SRAM and DRAM); and
- a DDR SRAM memory coupled to the processor (e.g., P. 20, L-Col., 4th Para – extern DRAM and SRAM; P. 20, L-Col., 4th Para – P. 21, L-Col., 1st Para – the SRAM is primarily used for packet descriptors, queue descriptors, counters, and other data structures; Fig. 2 – IXP 2400 internal architecture, element of “QDR SRAM”; Fig. 3 – IXP 2400-based OC-48 line card configuration, element of “DDR SDRAM”)

Lakshmanamurthy discloses the performance analysis methodology developed to analyze the performance of various networking applications that are targeted for running on the IXP2400 network processor (e.g., Abstract, 1st Para), but does not explicitly disclose:

- the memory including a compiler to cause transformation of a sequential network application program into D-application program stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the D-application program stages within a D-stage processor pipeline to provide parallel execution of the infinite PPS loop of the sequential network application program.

However, in an analogous art of *Network Processors: A Perspective on Market Requirements, Processor Architectures and Embedded SW Tools*, Paulin discloses:

- the memory including a compiler to cause transformation of a sequential network application program into D-application program stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the D-application program stages within a D-stage processor pipeline to provide parallel execution of the infinite PPS loop of the sequential network application program (e.g., Sec. 2 – Network Processing Unit Architecture, 3rd Para - ... A network processor ... integrated set of micro-coded or hardwired accelerated engines ... high-speed interconnect and media interfaces to tackle packet processing close to the wire. It uses pipelining, parallelism, and multi-threading to hide latency. IT has good data flow management and high-speed internal communication support. It has ability to access co-processor and is closely coupled with the media interface; Sec. 3.2 – FlexCC: Compilation Technology; Fig. 2 – STMicroelectronics NPU Architecture Overview; Sec. 2.2 NPU Design at STMicroelectronics, 2nd Para - ... instruction set definition, pipelining, parallelism, multithreading, fast interconnect, and semiconductor technology all combine to produce a network processor capable of OC-192 speeds and higher; 4th Para - ... achieved via pipelining ... a chain of pipelined processing units and flexible programmable elements; last Para - ... each packet processing engine will

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Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Paulin into the Lakshmanamurthy's system to further provide the following in Lakshmanamurthy system:

- the memory including a compiler to cause transformation of a sequential network application program into D-application program stages that collectively perform an infinite packet processing stage (PPS) loop of the sequential network application program to enable parallel execution of the D-application program stages within a D-stage processor pipeline to provide parallel execution of the infinite PPS loop of the sequential network application program.

The motivation is that it would further enhance the Lakshmanamurthy's system by taking, advancing and/or incorporating Paulin's system which offers significant advantages that the STMicroelectronics *FlexWare* embedded software environment is the basis of our NPU embedded S/W toolset, which will allow us to address the rapid changes in networking needs and customer requirement as once suggested by Paulin (e.g., Sec. 4 - Conclusion, 2nd Para)

10. Claims 2, 12, 32, and 35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lakshmanamurthy in view of Paulin and further in view of Rakhmatov et al., ("*Hardware-Software Bipartitioning for Dynamically Reconfigurable Systems*", May 2002, *ACM*) (hereinafter 'Rakhmatov')

11. **As to claim 2** (Original) (incorporating the rejection in claim 1), Lakshmanamurthy discloses network processor performance analysis methodology (e.g., Sec. of "ABSTRACT", 3rd Para), but Lakshmanamurthy and Paulin do not explicitly disclose transforming the sequential application program comprises constructing a flow network model for the sequential application program; selecting a plurality of preliminary pipeline stages from the flow network model; and modifying the preliminary pipeline stages to perform control flow and variable transmission therebetween to form the D-pipeline stages.

However, in an analogous art of *hardware-software bi-partitioning for dynamically reconfigurable systems*, Rakhmatov discloses transforming the sequential application program comprises constructing a flow network model for the sequential application program; selecting a plurality of preliminary pipeline stages from the flow network model; and modifying the preliminary pipeline stages to perform control flow and variable transmission therebetween to form the D-pipeline stages (e.g., Sec. of "ABSTRACT" – a method for mapping nodes of an application control flow graph either to software or reconfigurable hardware, explicitly targeting minimization of the energy-delay cost due to both computation and configuration; using network flow techniques,

after transforming the original control flow graph into an equivalent network; P. 145, R-Col., 1st Para through 3rd Para – the software can directly configure the hardware, which is partially reconfigurable; partial reconfiguration allows for a selective change of hardware segments of arbitrary size at an arbitrary location, without disrupting the operation of the rest of the hardware space; such a capability greatly reduces reconfiguration time and energy consumption, because the hardware updates are highly localized. Three types of problems: (1) energy-delay product minimization, (2) energy minimization under the delay constraint, and (3) delay minimization under the energy constraint can be resolved via using network flow techniques; specifically, the cost of a node depends whether it is in software or in hardware and the cost of an edge depends whether its origin node is in software or in hardware and whether its destination node is in software or in hardware; P. 146, L-Col., 2nd Para – 4th Para – the cost/weight can be either the energy or the delay or the energy-delay product of a node/edge, weighted by its execution frequency; first, transferring control from a hardware block to a software block is more expensive than transferring control from a software block to a software block; second, transferring control from a software block to a hardware block is more expensive than transferring control from a hardware block to a hardware block; P. 147, Sec. of “Constrained Bipartitioning Algorithms” – cost-driven constrained bi-partitioning; weight-driven constrained bi-partitioning; P. 148, R-Col., 1st Para; Fig. 3 – proposed constrained bi-partitioning algorithms)

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Rakhmatov into the

Lakshmanamurthy-Paulin's system to further provide transforming the sequential application program comprises constructing a flow network model for the sequential application program; selecting a plurality of preliminary pipeline stages from the flow network model; and modifying the preliminary pipeline stages to perform control flow and variable transmission therebetween to form the D-pipeline stages in

Lakshmanamurthy-Paulin system.

The motivation is that it would further enhance the Lakshmanamurthy- Paulin's system by taking, advancing and/or incorporating Rakhmatov's system which offers significant advantages for providing an efficient bi-partitioning algorithm that finds an optimal solution for energy-delay product minimization and systematically searches for the best in polynomially bounded set of good solutions for delay-constrained energy minimization, and energy-constrained delay minimization, the formulation also including costs and weights as design parameters as once suggested by Rakhmatov (e.g., Sec. of "CONCLUSION")

12. **As to claim 12** (Previously Presented) (incorporating the rejection in claim 11), please refer to claim 2 as set forth accordingly.

13. **As to claim 32** (Original) (incorporating the rejection in claim 31),

Lakshmanamurthy discloses network processor performance analysis methodology (e.g., Sec. of "ABSTRACT", 3rd Para), but Lakshmanamurthy and Paulin do not explicitly disclose the compiler to cause construction of a flow network model for the sequential

application program, to cause selection of a plurality of preliminary pipeline stages from the flow network model and to cause modification of the preliminary pipeline stages to perform control flow and variable transformation therebetween to form the D-pipeline stages.

However, in an analogous art of *hardware-software bi-partitioning for dynamically reconfigurable systems*, Rakhmatov discloses the compiler to cause construction of a flow network model for the sequential application program, to cause selection of a plurality of preliminary pipeline stages from the flow network model and to cause modification of the preliminary pipeline stages to perform control flow and variable transformation therebetween to form the D-pipeline stages (e.g., Sec. of "ABSTRACT" – a method for mapping nodes of an application control flow graph either to software or reconfigurable hardware, explicitly targeting minimization of the energy-delay cost due to both computation and configuration; using network flow techniques, after transforming the original control flow graph into an equivalent network; P. 145, R-Col., 1st Para through 3rd Para – the software can directly configure the hardware, which is partially reconfigurable; partial reconfiguration allows for a selective change of hardware segments of arbitrary size at an arbitrary location, without disrupting the operation of the rest of the hardware space; such a capability greatly reduces reconfiguration time and energy consumption, because the hardware updates are highly localized. Three types of problems: (1) energy-delay product minimization, (2) energy minimization under the delay constraint, and (3) delay minimization under the energy constraint can be resolved via using network flow techniques; specifically, the cost of a node depends

whether it is in software or in hardware and the cost of an edge depends whether its origin node is in software or in hardware and whether its destination node is in software or in hardware; P. 146, L-Col., 2nd Para – 4th Para – the cost/weight can be either the energy or the delay or the energy-delay product of a node/edge, weighted by its execution frequency; first, transferring control from a hardware block to a software block is more expensive than transferring control from a software block to a software block; second, transferring control from a software block to a hardware block is more expensive than transferring control from a hardware block to a hardware block; P. 147, Sec. of “Constrained Bipartitioning Algorithms” – cost-driven constrained bi-partitioning; weight-driven constrained bi-partitioning; P. 148, R-Col., 1st Para; Fig. 3 – proposed constrained bi-partitioning algorithms)

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Rakhmatov into the Lakshmanamurthy-Paulin's system to further provide the compiler to cause construction of a flow network model for the sequential application program, to cause selection of a plurality of preliminary pipeline stages from the flow network model and to cause modification of the preliminary pipeline stages to perform control flow and variable transformation therebetween to form the D-pipeline stages in Lakshmanamurthy-Paulin system.

The motivation is that it would further enhance the Lakshmanamurthy-Paulin's system by taking, advancing and/or incorporating Rakhmatov's system which offers significant advantages for providing an efficient bi-partitioning algorithm that finds an

optimal solution for energy-delay product minimization and systematically searches for the best in polynomially bounded set of good solutions for delay-constrained energy minimization, and energy-constrained delay minimization, the formulation also including costs and weights as design parameters as once suggested by Rakhmatov (e.g., Sec. of "CONCLUSION")

14. **As to claim 35** (Original) (incorporating the rejection in claim 34), please refer to claim 32 as set forth accordingly.

15. Claims 3-4, 8, 10, 13-14, 18, 20, 33, and 36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lakshmanamurthy in view of Paulin, Rakhmatov and further in view of Robschink et al., ("*Efficient Path Conditions in Dependence Graphs*", May 2002, ACM) (hereinafter 'Robschink')

16. **As to claim 3** (Original) (incorporating the rejection in claim 2), Rakhmatov discloses constructing the flow network model (e.g., Sec. of "ABSTRACT" – a method for mapping nodes of an application control flow graph either to software or reconfigurable hardware, explicitly targeting minimization of energy-delay cost due to both computation and configuration; show how these problems can be tackled by using network flow techniques, after transforming the original control flow graph into an equivalent network), but Lakshmanamurthy, Paulin and Rakhmatov do not explicitly disclose transforming the application program into a static, single-assignment form;

building a control flow graph for a loop body of the application program; building a dependence graph based on a summary graph of the control flow graph and identified, strongly-connected components (SSC) of the control flow graph; and constructing the flow network model according to a summary graph of the dependence graph and identified SSC nodes of the dependence graph.

However, in an analogous art of *efficient path conditions in dependence graphs*, *Robschink* discloses transforming the application program into a static, single-assignment form (e.g., Sec. 2.2 – Path conditions, 2nd Pa. – since there may be assignments to the same variable at different program points, all programs must be transformed into static single assignment form (SSA) first. In SSA form, there is at most one assignment to every variable. If necessary, we will distinguish different SSA-variants of a program variable by additional indices; P. 480, 3rd Para – since the program is transformed to SSA form first, some additional constraints must be generated which represent the Φ -function occurring in SSA form); building a control flow graph for a loop body of the application program; building a dependence graph based on a summary graph of the control flow graph (e.g., Sec. 1 – Introduction, 4th Para – *Va/Soft* can build a dependence graph for 50000 lines of C; forward and backward slices or chops can be interactively computed and visualized in the source text; Fig. 1 – a *mergesort* program and part of its SDG (System Dependence Graph); Sec. 2.1 – Dependence and slices, 2nd Para – slices can be defined via the system dependence graph (SDG); Sec. 3 – Basic Analysis, 1st Para; Sec. 3.1 – Analyzing data flow, 1st Para) and identified, strongly-connected components (SSC) of the control flow

graph; and constructing the flow network model according to a summary graph of the dependence graph and identified SSC nodes of the dependence graph (e.g., Sec. 4.2 – Exploiting interval analysis, 2nd Par through 3rd Para)

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Robschink into the Lakshmanamurthy-Paulin-Rakhmatov's system to further provide transforming the application program into a static, single-assignment form; building a control flow graph for a loop body of the application program; building a dependence graph based on a summary graph of the control flow graph and identified, strongly-connected components (SSC) of the control flow graph; and constructing the flow network model according to a summary graph of the dependence graph and identified SSC nodes of the dependence graph in Lakshmanamurthy-Paulin-Rakhmatov system.

The motivation is that it would further enhance the Lakshmanamurthy- Paulin-Rakhmatov's system by taking, advancing and/or incorporating Robschink's system which offers that path conditions in dependence graphs are a valuable tool for various kinds of program analysis, such as program understanding or safety checks as once suggested by Robschink (e.g., Sec. of "CONCLUSION AND FUTURE WORK", 1st Para)

17. **As to claim 4** (Original) (incorporating the rejection in claim 3), Rakhmatov discloses constructing the flow network model comprises assigning a unique source node and a unique sink node to the flow network model (e.g., Sec. 4 – Proposed Solution, 1st Para)

Robschink discloses adding a program node to the flow network model for each SSC node identified in the summary graph of the dependence graph (e.g., Sec. 2.2 – Path conditions, 2nd Para. – since there may be assignments to the same variable at different program points, all programs must be transformed into static single assignment form (SSA) first. In SSA form, there is at most one assignment to every variable. If necessary, we will distinguish different SSA-variants of a program variable by additional indices; P. 480, 3rd Para – since the program is transformed to SSA form first, some additional constraints must be generated which represent the Φ -function occurring in SSA form); adding a variable node to the flow network model for each variable that is defined and used by multiple program nodes; adding a control node C to the flow network model for each SSC node identified in the summary graph of the dependence graph as a source of control dependence (e.g., Sec. 1 – Introduction, 4th Para – *ValSoft* can build a dependence graph for 50000 lines of C; forward and backward slices or chops can be interactively computed and visualized in the source text; Fig. 1 – a *mergesort* program and part of its SDG (System Dependence Graph); Sec. 2.1 – Dependence and slices, 2nd Para – slices can be defined via the system dependence graph (SDG); Sec. 3 – Basic Analysis, 1st Para; Sec. 3.1 – Analyzing data flow, 1st Para)

Further, Rakhmatov discloses generating edges having an associated weight to connect corresponding program nodes to corresponding variable nodes; generating edges having an associated weight to connect corresponding program nodes to corresponding control nodes; and generating edges between the program nodes and one of the source node and the sink node (e.g., Sec. 2 – Problem Description, 1st Para

through 4th Para, and 6th Para; P. 147, L-Col., 1st Para; Sec. 4 – Proposed Solution, 1st Para through 2nd Para; P. 147, R-Col., 1st Para through 4th Para)

18. **As to claim 8 (Original)** (incorporating the rejection in claim 2), Rakhmatov discloses selecting the plurality of preliminary pipeline stages comprises cutting the flow network model into D-1 successive cuts, such that each cut is a balanced minimum cost cut (e.g., Sec. 1 – Introduction, 4th Para – cost function involve costs of all nodes and all edges in the CFG, and not just the edges in the cut-set separating software-mapped nodes and hardware-mapped nodes; specifically, the cost of a node depends whether it is in software or in hardware, and the cost of an edge depends whether its origin node is in software or in hardware and whether its destination node is in software or in hardware; Sec. 3 – Related Work, 2nd Para (Circuit Partitioning) Through 3rd Para, 6th Para (Our Contribution) – our contribution is to show how a CFG (Control Flow Graph) with node and edge costs can be transformed into a network, so that a minimum cut in the network corresponds to an optimal bi-partition of the CFG; P. 147, 1st Para through 2nd Para; Fig. 2 – unconstrained bi-partitioning algorithm – $CUT = FindMinCut(V, E)$)

19. **As to claim 10 (Previously Presented)** (incorporating the rejection in claim 2), Rakhmatov discloses modifying the preliminary pipeline stages comprises (a) selecting a preliminary pipeline stage; (b) altering the selected preliminary pipeline stage to enable proper transmission of live variables; and control flow to and from the selected preliminary pipeline stage; and (c) (a) – (b) for each preliminary pipeline stage to form

the D-pipeline stages of a parallel network application (e.g., Sec. of "ABSTRACT" – a method for mapping nodes of an application control flow graph either to software or reconfigurable hardware, explicitly targeting minimization of the energy-delay cost due to both computation and configuration; using network flow techniques, after transforming the original control flow graph into an equivalent network; P. 145, R-Col., 1st Para Through 3rd Para – the software can directly configure the hardware, which is partially reconfigurable; partial reconfiguration allows for a selective change of hardware segments of arbitrary size at an arbitrary location, without disrupting the operation of the rest of the hardware space; such a capability greatly reduces reconfiguration time and energy consumption, because the hardware updates are highly localized. Three types of problems: (1) energy-delay product minimization, (2) energy minimization under the delay constraint, and (3) delay minimization under the energy constraint can be resolved via using network flow techniques; specifically, the cost of a node depends whether it is in software or in hardware and the cost of an edge depends whether its origin node is in software or in hardware and whether its destination node is in software or in hardware; P. 146, L-Col., 2nd Para – 4th Para – the cost/weight can be either the energy or the delay or the energy-delay product of a node/edge, weighted by its execution frequency; first, transferring control from a hardware block to a software block is more expensive than transferring control from a software block to a software block; second, transferring control from a software block to a hardware block is more expensive than transferring control from a hardware block to a hardware block; P. 147, Sec. of "Constrained Bipartitioning Algorithms" – cost-driven constrained bi-partitioning;

weight-driven constrained bi-partitioning; P. 148, R-Col., 1st Para; Fig. 3 – proposed constrained bi-partitioning algorithms)

20. **As to claim 13** (Original) (incorporating the rejection in claim 12), please refer to claim 3 as set forth accordingly.

21. **As to claim 14** (Original) (incorporating the rejection in claim 13), please refer to claim 4 as set forth accordingly.

22. **As to claim 18** (Original) (incorporating the rejection in claim 12), please refer to claim 8 as set forth accordingly.

23. **As to claim 20** (Original) (incorporating the rejection in claim 12), please refer to claim 10 as set forth accordingly.

24. **As to claim 33** (Original) (incorporating the rejection in claim 32), Robschink discloses the compiler to cause D-1 successive cuts of the flow network mode, such that each cut is a balanced, minimum cost cut to form the D-preliminary pipeline stages (e.g., Sec. 1 – Introduction, 4th Para – cost function involve costs of all nodes and all edges in the CFG, and not just the edges in the cut-set separating software-mapped nodes and hardware-mapped nodes; specifically, the cost of a node depends whether it is in software or in hardware, and the cost of an edge depends whether its origin node is

in software or in hardware and whether its destination node is in software or in hardware; Sec. 3 – Related Work, 2nd Para (Circuit Partitioning) Through 3rd Para, 6th Para (Our Contribution) – our contribution is to show how a CFG (Control Flow Graph) with node and edge costs can be transformed into a network, so that a minimum cut in the network corresponds to an optimal bi-partition of the CFG; P. 147, 1st Para through 2nd Para; Fig. 2 – unconstrained bi-partitioning algorithm – $CUT = FindMinCut(V,E)$

25. **As to claim 36** (Original) (incorporating the rejection in claim 35), please refer to claim 33 as set forth accordingly.

26. Claims 9 and 19 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lakshmanamurthy in view of Paulin, Rakhmatov and Robschink and further in view of Goldberg et al., (*"A New Approach to the Maximum-Flow Problem"*, 1988, *ACM*) (hereinafter 'Goldberg')

27. **As to claim 9** (Original) (incorporating the rejection in claim 8), Lakshmanamurthy, Paulin, Rakhmatov, and Robschink do not disclose that cutting is performed using an iterative balanced to push-relabel algorithm.

However, in an analogous art of a new approach to the maximum-flow problem, Goldberg discloses cutting is performed using an iterative balanced to push-relabel algorithm (e.g., P. 922, 4th Para – the algorithm pushes flow through the network to find a blocking flow, which determines the acyclic network for the next phase; our algorithm

maintains a pre-flow in the original network and pushes local flow excess toward the sink along what it estimates to be shortest paths in the residual graph; P. 924, 4th Para – the pre-flow algorithm works by examining vertices other than s and t with positive flow excess and pushing excess from them to vertices estimated to be closer to the sink t , with the goal of getting as much excess as possible to t .)

Therefore, it would have been obvious to one of ordinary skill in the art, at the time the invention was made to combine the teachings of Goldberg into the Lakshmanamurthy-Paulin-Rakhmatov-Robschink's system to further provide that cutting is performed using an iterative balanced to push-relabel algorithm in Lakshmanamurthy-Paulin-Rakhmatov-Robschink system.

The motivation is that it would further enhance the Lakshmanamurthy-Rakhmatov-Paulin-Robschink's system by taking, advancing and/or incorporating Goldberg's system which offers significant advantages that the method maintains a pre-flow in the original network and pushes local flow excess toward the sink along what are estimated to be shortest paths as once suggested by Goldberg (e.g., P. 921, 1st Para)

28. **As to claim 19** (Original) (incorporating the rejection in claim 18), please refer to claim **9** as set forth accordingly.

Allowable Subject Matter

29. Claims 5-7, 15-17, 22-25 and 27-30 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten to overcome the rejections under 35 U.S.C. 103(a) set forth in this office action and to include all the limitations of the base claim and any intervening claims.

The following is an examiner's statement of reasons for allowance:

Regarding claims 5-7, 15-17, 22-25, and 27-30, prior art of record fails to reasonably show or suggest the specific edge generations having associated weights, transformation of the preliminary application program stage, and transformation of the control flow as claimed. Specifically, the methods to generate edges having an associated weight to connect corresponding program nodes to (1) corresponding variable nodes, (2) corresponding controls nodes; the method to generate the edges between program nodes and one of the source node and the sink nodes; transformation of the preliminary application program stages; and transformation of the control flow in details.

Conclusion

30. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ben C. Wang whose telephone number is 571-270-

1240. The examiner can normally be reached on Monday - Friday, 8:00 a.m. - 5:00 p.m., EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tuan Q. Dam can be reached on 571-272-3695. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Ben C Wang/
Examiner, Art Unit 2192

/Eric B. Kiss/
Eric B. Kiss
Primary Examiner, Art Unit 2192

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